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[1]Florida State University, United States; [2]Raytheon Technologies Research Center, United States

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A Merged H-Bridge Based Switched Tank Converter for Front-End Voltage Regulator Modules [#1868] 1995
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A Hybrid Si/SiC Interleaved Bidirectional DC-DC Converter to Optimal Power Quality, Efficiency, and Cost Tradeoff [#1641] 2001
Kun Qu, Chao Zhang, Weibin Chen, Bo Hu, Jing Chen, Jun Wang
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Analytic Model and Design Procedure of the Single-Secondary Trans-Inductor Voltage Regulator [#2023] 2005
Hang Shao, Tao Zhao, Dianbo Fu, Daocheng Huang, Jinghai Zhou
Monolithic Power Systems, Inc., United States

An Ultrahigh Step-Down DC-DC Converter Based on Switched-Capacitor and Coupled Inductor Techniques [#1405] 2011
Longyang Yu[1], Chengzi Yang[1], Wei Mu[1], Fengtao Yang[1], Huaqing Li[1], Laili Wang[1], Yuquan Su[2], Chi Zhang[2]
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